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Superparamagnetic Sensor with Lateral Flow Immunoassays as Platforms for Biomarker Quantification

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Abstract : Biosensors play a crucial role in the detection of molecules nowadays due to their advantages of user-friendliness, high selectivity, the analysis in real time and in-situ applications. Among them, Lateral Flow Immunoassays (LFIAs) are presented among technologies for point-of-care bioassays with outstanding characteristics such as affordability, portability and low-cost. They have been widely used for the detection of a vast range of biomarkers, which do not only include proteins but also nucleic acids and even whole cells. Although the LFIA has traditionally been a positive/negative test, tremendous efforts are being done to add to the method the quantifying capability based on the combination of suitable labels and a proper sensor. One of the most successful approaches involves the use of magnetic sensors for detection of magnetic labels. Bringing together the required characteristics mentioned before, our research group has developed a biosensor to detect biomolecules. Superparamagnetic nanoparticles (SPNPs) together with LFIAs play the fundamental roles. SPMNPs are detected by their interaction with a high-frequency current flowing on a printed micro track. By means of the instant and proportional variation of the impedance of this track provoked by the presence of the SPNPs, quantitative and rapid measurement of the number of particles can be obtained. This way of detection requires no external magnetic field application, which reduces the device complexity. On the other hand, the major limitations of LFIAs are that they are only qualitative or semiquantitative when traditional gold or latex nanoparticles are used as color labels. Moreover, the necessity of always-constant ambient conditions to get reproducible results, the exclusive detection of the nanoparticles on the surface of the membrane, and the short durability of the signal are drawbacks that can be advantageously overcome with the design of magnetically labeled LFIAs. The approach followed was to coat the SPIONs with a specific monoclonal antibody which targets the protein under consideration by chemical bonds. Then, a sandwich-type immunoassay was prepared by printing onto the nitrocellulose membrane strip a second antibody against a different epitope of the protein (test line) and an IgG antibody (control line). When the sample flows along the strip, the SPION-labeled proteins are immobilized at the test line, which provides magnetic signal as described before. Preliminary results using this practical combination for the detection and quantification of the Prostatic-Specific Antigen (PSA) shows the validity and consistency of the technique in the clinical range, where a PSA level of 4.0 ng/mL is the established upper normal limit. Moreover, a LOD of 0.25 ng/mL was calculated with a confident level of 3 according to the IUPAC Gold Book definition. Its versatility has also been proved with the detection of other biomolecules such as troponin I (cardiac injury biomarker) or histamine.

Keywords : biosensor, lateral flow immunoassays, point-of-care devices, superparamagnetic nanoparticles
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